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Stability of a rolling fluid filled cylinder ROHIT SUPEKAR, MAHESH PANCHAGNULA, Indian Institute of Technology Madras — We present an analytical solution to the problem of a fluid filled hollow cylindrical shell rolling on an inclined plane and then investigate the temporal stability of the system using linear stability analysis. We study the motion in two dimensions by analyzing the interaction between the fluid and the hollow cylinder. We show that the terminal state is associated with a constant acceleration, similar to a rigid body motion. Surprisingly, it is independent of the liquid viscosity and only depends on the ratio of the mass of the shell to the mass of the fluid contained (say, π_{m}). We analyze this base flow for its stability behavior using the frozen-time approximation. In this approach, we treat time as a parameter, the evolution of which causes the flow to transition from a stable to an unstable state. The point of neutral stability is noted and the spatial modes that show the maximum growth rate are analyzed. It was observed that instability sets in due to long wavelength axial waves, which are transverse to the flow direction. We find a critical Reynolds number based on the time to instability, above which the flow becomes unstable. Again, this Reynolds number appears to be only a function of π_{m}.

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